Speeches M.S.
2/1/18

Proposed Publication on Methods of Estimating Insect Losses.

Section 1.

Title, Scope and Purpose.

Forest insect reconnaissance is the term applied to methods of estimating insect losses in timber stands. It involves the use of practical methods of timber estimating to determine the quantity and character of insect-killed timber, and an elementary understanding of forest entomology in order that the work of the more important tree-killing insects may be recognized.

The origin of forest insect reconnaissance in the United States dates back to the first work by Dr. A. D. Hopkins in West Virginia in 1885 to 1895. The work which was started here has served as a foundation for all branches of applied forest entomology in this country. The earlier publications of this author first brought to public notice the importance of the insect control problem and emphasized the fact that forest entomology must be considered in any system of progressive forestry. From this earlier work has been built up the present insect control organizations of the Forest Service and the branch of forest insect investigations of the Bureau of Entomology in the United States Department of Agriculture.

A growing realization of the importance of forest entomology in the protection of public and private forests and of National Parks, has brought with it the need for standard methods which will express the applied problems of this science in terms of forest values. It is essential that the damage caused by insects be expressed in a quantitative way before its ultimate effect upon forest resources can be appreciated. A record of the mere presence of tree infesting insects in timber stands is not sufficient data upon which to formulate a policy of forest protection.

Any method of forest reconnaissance, to be practical, must meet two essential requisites. First the data secured must be of sufficient accuracy to warrant its use in forest management; and, second, the cost must be in keeping with the value of the data. There is no system of forest accounting by which a method can be made to pay for itself if it costs $500.00 to determine that the loss from insects on 1000 acres amounts to $100.00 in the stumpage value.

The forests of the Pacific Slope and Rocky Mountain regions embrace vast areas of virgin stands, and any system of preliminary insect reconnaissance which involves the examination of every tree must necessarily be discarded from consideration. The examination of the present forests of the west must, for the most part, be conducted by extensive methods which will permit of the examination of large areas in a comparatively short time.

A specialized knowledge of entomology, while desirable, is by no means essential, as a requisite for the conduct of forest insect surveys. If the estimator, is able to recognize the few important species by the nature of their work upon the trees, he can successfully carry on reconnaissance work without attempting to classify the insects. If an authoritative determination of the insects is essential, specimens should by all means be referred to recognized authorities on the systematic groups.

In conducting forest insect surveys, the emphasis should be placed upon the

accuracy and adaptability of the methods used in estimates. Technical matters relating to entomology belong to distinct field of investigations and to give them an unnecessary amount of consideration may result in sacrificing entirely the practical phases of reconnaissance work.

The aim of the present publication is to present this subject from the standpoint of practical surveys, and the entomological features are left to the publications of the Bureau of Entomology.

Section IV.

EVIDENCES OF INSECT INFESTED AND DEAD ABANDONED TREES.

In as much as practical methods of reconnaissance require that the total loss must be estimated upon the basis of trees seen and counted from a distance, foliage is the only indication upon which the cruiser can rely in distinguishing infested or dead abandoned trees. After attack the needles of conifers turn a noticeably paler green, later take on a yellowish tinge which soon turns to a red or reddish brown color. After one or two winters these needles blacken and fall and the tree becomes a black top which cannot easily be distinguished at a distance. As a basis for his estimates, the cruiser must depend almost entirely upon his ability to distinguish and count trees after the first fading appears and before the black top stage is reached.

In certain stands and types of infestation, such as the western pine beetle in yellow pine in the Pacific Slope Region, foliage is a much more important and reliable criterion than in others. In the mountain pine beetle infestation, in lodgepole pine and yellow pine, the foliage fades too late to be a useful factor in locating freshly infested trees. However, in any system of extensive reconnaissance, the evidence supplied by the foliage must always remain the first index to the condition of a forest. The estimator who fails to properly interpret foliage evidences, can never estimate successfully insect loss on a large forested area.

Certain terms are essential in describing the color phases of infested trees and a set of standard terms have been defined by Dr. Hopkins in Bulletin 83. It is essential to adhere to established basic terms although there are variations to all the color phases of trees and colors and the various stages merge sometimes so that they are difficult to distinguish. It is also essential that as few terms as will possibly [illegible] the requirements of practical work should be adopted in order to limit the possibility of confusion in the interpretation of color phases. The following definitions in quotation are those given by Dr. Hopkins in Bulletin 83:

Fading tops - "The fading or noticeably paler green of the foliage of infested trees."

This is the first indication of the foliage by which it is possible to distinguish an infested tree. In its first stages it applies to a sickly appearance of the needles although there is no appreciable change in color. Fading foliage passes rapidly to a greenish white, yellow or even red color.

Sorrel tops - "The yellowish foliage of trees dying from the attacks of beetles."

Sorrel foliage appears within a month or two after the trees fade. Several phases of colored foliage are classed as sorrel top, varying from a greenish white to yellow with a distinct reddish tinge. Sorrel tops may last for several months before they turn red.

Red tops - "The color of the foliage after the tree is dead and usually after the broods of destructive beetles have emerged from the bark."

This is a distinct phase of color appearing from two to six months after the trees fade. Red top trees are not as conspicuous as sorrel top trees because of the much darker color of the foliage. Needles of red top trees gradually darken but can [illegible]ally be classed as red as long as they adhere to the tree. The red top state disappears when the needles fall or enough of them fall so that the tree is not easily distinguished at a distance and is classed as a black top. The red top stage usually

lasts until the second winter after the tree fades, although many trees lose most of their red needles after the first winter.

Black top - "The condition of the dead trees after all of the leaves have fallen and two or more years after the beetles have left them."

This condition is reached gradually. The needles usually fall first from the upper part of the tree. A tree will have a black top although there are still a few red needles adhering to the lower limbs. From a distance such trees cannot be distinguished and are classed as black tops.

Many trees turn black after the first hard winter and practically all trees reach the black top stage after the second winter.

The black top stage lastsauntil the bark begins to fall from the trunk and limbs. The extent of this period has not been determined but it apparently lasts for from six to eight years.

Ghost trees - This term has been proposed by Dr. Hopkins to describe the final stage of the standing insect killed trees. It appears after the bark has fallen from the trunk and limbs and the white sapwood of the trunk makes them conspicuous. Many insect-killed trees do not reach the ghost tree stage as decay, borers or windstorms cause them to fall during the black top period.

Application of Terms.

The estimator is obliged to depend almost entirely upon the first three color phases of the foliage as the basis of his counts of insect infested and abandoned trees. Fading, sorrel and red trees which can be distinguished from healthy trees in the forest at a considerable distance, represent an approximately definite period of recent loss. Black top trees are very difficult to see even from a short distance and the period of loss which they represent is too indefinite and too remote to form any conclusions in regard to existing conditions.

It is sometimes difficult to accurately separate the color phases belonging to fading, sorrel and red trees as one stage merges into another, and the individual color perceptions of different estimators will result in different interpretations of the color phases of the same tree. For all practical purposes it has been determined that the best method in extensive reconnaissance is to count all faded top, sorrel top and red top trees. It has been determined that these will represent a certain number of insect infested and abandoned trees representing a period of loss of approximately 2 years. In apportioning the loss represented according to years the estimator must depend entirely upon sample plots and the trees which were actually examined.

The color development of individual trees is extremely variable. Young trees which have grown rapidly become almost white before turning yellow while older mature trees fade and then turn red without passing through a sorrel stage. Some trees retain the foliage twice as long as others.

Red top trees are usually abandoned. The term "faded trees" is used to indicate any phase of the foliage after it has colored sufficiently to detect the tree.

Infested trees can first be detected in the fading or sorrel top stage. For practical purposes it is unnecessary to distinguish between these two stages, as both

indicate infested trees. As a rule trees turn red about the time that the new beetles are emerging, so that red tops can be counted as abandoned trees. Studies made by F. P. Keen, of the western pine beetle in yellow pine, show that in general, trees infested by this species fade while the infesting broods are in the larval stage, turn sorrel just after the period of maximum puparion, and become red at the time of the maximum emergence of the beetles. Varying exceptions to this rule can be found, such as trees turning red soon after attack and trees which do not fade until the broods are almost ready to emerge, but on the whole these general statements may be relied upon for the purpose of reconnaissance.

COLOR PHASES AS MODIFIED BY THE SEASONAL HISTORY AND GENERATIONS OF DENDROCTONUS BEETLES.

Limitations of Insect Control Problems.

In his classification of the Genus Dendroctonus in Bulletin 83, Plate I, Dr. Hopkins groups the species of these two beetles in two main divisions. Practically all of the serious insect control problems which have developed to date have b been in pine stands and are confined to species belonging to Division I. These consist of two species of the *brevicomis* type (Western pine beetle and the closely related southwestern pine beetle), and three species of the *monticolae* type (Mountain pine beetle, Black Hills beetle and Jeffrey pine beetle). Other species which infest Douglas fir and spruce have for the most part confined their attacks to weakened and injured trees and logs and no epidemics have been recorded which involved the extensive killing of healthy trees. The western pine beetle is by far the most important insect enemy of western yellow pine in Southern Oregon and California, being responsible for the greater percent of the total annual loss. The mountain pine beetle is the primary enemy of sugar pine throughout its ranges. It also kills great bodies of lodgepole pine and western white pine, and is the more important enemy of yellow pine east of the Cascade Mountains. The Jeffrey pine beetle is the only important enemy of Jeffrey pine. Other Dendroctonus beetles of the mountain pine beetle type are of importance only in the Rocky Mountain region.

Relation of Annual Loss to Seasonal History.

The western pine beetle and the southwestern pine beetle develop more than one generation annually. In warmer localities the western pine beetle is able to developtwo complete generations and a partial third. Through the greater part of its range however, it develops one complete annual generation and a partial second.

Beetles of the mountain pine beetle group develop but one complete annual generation. In some localities there appears to be the partial development of a second generation but at higher elevations where there is a short summer season there is only one incomplete annual generation.

In any specie or locality the possibilities of overlapping of generations a are innumerable and they cannot be separated in computing annual loss. The only practically basis for comparing the loss of one year with that of another, is to compare the total annual loss of all seasonal generations.

Seasonal generations cannot be entirely disregarded, however, in estimating loss, where more than one annual generation develops. This is due to the fact that trees which are attacked in the spring and early summer fade and are abandoned before fall while those trees which are attacked late in the season remain infested during the following winter months. Both classes of trees, however, compose the annual loss

of the same year and the use of terms to designate them seems essential. First generation trees are therefore those which are attacked so early in the season that they are abandoned before winter. Second generation trees are those attacked during the same season but late enough that the broods do not complete development before winter and emerge the following season. These terms are needed only in referring to trees infested by beetles of the western pine beetle type. They do not however relate to the true generations of beetles and should not be confused with the development of seasonal generations as these terms apply to the trees and not to the beetles.

EVIDENCES OF ATTACK BY SPECIES OF THE WESTERN PINE BEETLE TYPE.

Foliage.

Trees attacked by the western pine beetle fade rapidly after attack and change from fading top to sorrel and red tops within a few months. There are variations of all three stages some of which have only local significance. The needles of trees which fade during the warmer months often take on light straw colored or silvery yellow appearance before they turn deep sorrel which has led to the term of "white top". This is only a phase of the sorrel top stage, however, and is without general significance. The first phase of the red top stage is usually a bright red appearance of the needles which turn gradually to dull red or red brown.

Trees of the first seasonal generation which are attacked during the spring and early summer fade within a month or so after attack. The heaviest period of fading is during July and practically all have faded by the first of August.

Trees of the second seasonal generation begin to fade the last of August and from 25% to 75% of them fade before winter. During the winter months there is a check in development of the color phases. Trees of the second generation which were green during the winter begin fading in the spring and usually all have faded by the last of May.

Red top trees which have passed through the winter have dull red drooping needles. More than half of these trees are black before the second winter and practically all turn black before the third winter.

Evidence of Attack in the Bole.

Pitch tubes of sufficient size to be discernible appear rarely and cannot be relied upon as an evidence of attack. The only satisfactory means of identifying the infestation of this species is to knock off the bark so that the characteristic egg-galleries of the beetles can be readily seen. To locate the advanced stages of the broods, it is necessary to chip off the outer scales of the bark, cutting just deep enough to uncover larvae, pupae and new adults. Sawdust borings are also scant and seldom plentiful enough to be conspicuous.

The only reliable evidence of infestation aside from a basal examination of the bark, is that of woodpecker work. Woodpeckers in feeding upon the western pine beetle, look for advance stages of the broods and knock off only the outer scales of bark. This habit, gives a characteristic appearance to the work quite different from that produced by bird work on the mountain pine beetle.

EVIDENCE OF ATTACK BY BEETLES OF THE MOUNTAIN PINE BEETLE TYPE.

Foliage.

On the whole the loss caused by this species can be estimated upon the basis of one complete annual generation, and the complications due to first or second generation trees do not enter in to the computation.

Trees fade slowly after attack, and the majority of trees which are attacked during the summer and fall do not fade until the following spring. The color phases pass rapidly from fading to sorrel and red. Red foliage normally persists through the first winter and the next summer but turn black before the end of the second winter. Trees which fade in the spring are red during the first summer and winter but turn black during the second spring or summer. There are however exceptions as in the case of the western pine beetle.

Attack on Bole.

Pitch tubes are one of the most reliable evidences of attack by species of this group. The number and size of pitch tubes seem to depend to a very great extent upon the vitality of the attacked trees. Weakened and decadent trees do not produce noticeable pitch tubes. This is true of large mature sugar pines attacked by the mountain pine beetle. Where the attack, however, is upon strong thrifty trees pitch tubes become conspicuous within a week or so after attack. This is especially true of yellow pine and lodgepole pine.

Sawdust borings produced by this species are coarse and plentiful enough to be used in locating attacks. Some of these borings lodge in the crevices but there is an accumulation of them near the base of the tree.

Woodpeckers work upon the broods in advanced stages and their work usually consists of irregular holes in the bark over the pupal cells of the beetles. This work is quite distinct in appearance from that which results from bird work on western pine beetle infestation.

During the fall and winter months it is possible to locate a fair percentage of the trees only by depending upon the evidences which can be found upon the bole. This is especially true of lodgepole pine in the higher elevations which seldom fades before spring. The fading of the foliage occurs too late upon whole to be serviceable in locating infested trees for control work.

OTHER FACTORS CONTRIBUTING TO FADING FOLIAGE.

During some seasons many trees will fade at the top while the lower limbs remain green and the bole near the base shows no indication of insect attack. This fading condition may extend over the entire foliage while a basal examination fails to reveal insects in any stage of development or attack. In the yellow pine and sugar pine stands in California fading top trees are sometimes as numerous as infested trees.

Faded trees in which Dendroctonus Beetles cannot be Detected.

Trees on which the entire foliage is fading as though attacked by Dendroctonus beetles but a basal examination of which shows no infestation or an unsuccessful attack are also a source of confusion in forming estimates.

Sour sap trees.

The attack of Dendroctonus beetles sometimes appears to cut off the normal flow of sap in such a way that a great abundance of moisture settles in the inner bark

within the lower ten or twenty of the bole. This excess of moisture kills the immature stages of the brood and causes the parent adults to abandon the attack entirely. A great many trees exhibit this condition only in the lower three or four feet while in others it extends much higher. Above the point where this condition exists the infestation may be normal in all respects.

Other insects, such as flathead borers, roundhead borers engraver beetles, etc., sometimes appear as the primary cause in the entire killing of trees.

The red turpentine beetle, Dendroctonus valens frequently is found at the base of fading trees which show no evidence of other attacks. As a rule where the attack of this species occurs it will be found that some other agency is affecting the upper portion of the tree. While this specie is very common and is always found associated with the epidemics of other barkbeetles, it is rarely found to be the only infesting insect in a dying tree. Tree killing epidemics of the turpentine beetle in commercial forests have not been recorded.

Other causes which produce the fading of the entire tree are certain disease affecting the bole, limbs, needles and twigs. The diagnosis of trees so affected falls within the province of Forest Pathology. Conditions have been found locally where trees were affected with diseases of a character to cause confusion in the estimates of insect loss by extensive reconnaissance.

Fire scorching.

Trees which have been scorched by fire sometimes take on a color phase resembling the red top stage of insect-killed trees. As a rule however scorched trees do not pass through the fading and sorrel top stages of insect-killed trees and they can be distinguished even at a distance from infested trees. Upon close examination the evidences of fire are, of course, unmistakable.

Unknown causes

Many dying trees will also be found which cannot be explained by any of the common causes mentioned. This may be due to organic disturbances, but in any case a diagnosis of the cause requires specialized knowledge and more time than can be afforded in estimate work. Trees dying from unknown causes often form a very appreciable percent of the total loss.

Top-killed trees.

Attacks by Dendroctonus beetles.

Occasionally Dendroctonus beetles attack near the top of the tree only, leaving the base unmolested. In the case of yellow pine this happens rarely and the attack is usually associated with that of other species, such as engraver beetles and flat head borers. The western pine beetle is less likely to be found in these top-killing attacks than the mountain pine beetle which is occasionally found in the tops only of large matur trees.

The mountain pine beetle is found most frequently in the top-killing of sugar pine in California. Many of these large trees are attacked and the upper half of the tree only killed in one season. As a rule, however, the lower part will be attacked and the tree completely killed within one or two seasons after the initial top-killing. In thin barked trees such as young yellow pine, sugar pine and all ages of lodgepole pine the attack begins at the base and top-killing in trees of this character is due to other causes.

Engraver beetles.

Damage caused by species of this group (Ips Pityophthorus, etc) is confined to the killing of groups of small trees in pole and sapling stands, and the top-killing of larger trees. This damage has been observed to appear in the form of sporadic epidemics which develop and subside within one or two seasons.

Certain species of engraver beetles (Ips confusus) have been observed to cause widespread top-killing in yellow pine. Color phases following the attack of this species closely resemble those of western pine beetle attacks. In counting trees from a distance it is frequently difficult to distinguish top-killed trees from Dendroctonus infested trees so that the cruiser must depend largely upon the ratio of trees actually examined for distinguishing between these types of infestation.

Other causes of top-killing.

Trees are occasionally top-killed from other causes. Among these are flat-head and round-head larvae, the effects of pitch moth infestation, and agencies aside from insects. Among these may be mentioned disease, lightning, porcupine work, etc.

The only reliable way to determine the cause of top-killing is to cut or climb the tree and examine the affected portion. This method requires more time than can be spared in general reconnaissance cruising. Certain evidences, however, such as woodpecker work after insects, pitch tubes, mechanical injury, etc, can be seen from the ground, give an indication of the cause and can be used in extensive work.

CRUISING PERIODS.

Of fundamental importance in the interpretation of data is an understanding of the seasonal conditions of the period during which the field examination is made.

Normally there are four cruising periods corresponding to the four annual seasons. The faded trees which can be counted during one season may represent a different period of loss from those counted during another period of the same year. A knowledge of the character of the data which may be secured during any period is essential for an intelligent reconnaissance in a locality.

Some periods may possess very evident advantages over others for conducting field work. To a great extent these advantages vary locally depending upon weather conditions. In some regions winter reconnaissance is practical while in other localities any attempt to carry on extensive reconnaissance during the period involves great loss of time and waste of effort. Periods of rain, snow, fog and dark cloudy weather cannot be utilized at all for extensive viewing. The estimator must depend largely upon periods of bright clear weather for field work in insect Reconnaissance. For this reason the spring, summer and fall periods offer the more favorable conditions. Late spring and early summer usually offer the best conditions of the entire year for reconnaissance work. During the late summer and early fall especially if the season has been rainless, atmospheric conditions may again hamper field work because of an atmospheric haze which obscured the distance. If forest fires are prevalent it is impossible to conduct satisfactory work until the atmosphere is cleared by rain or other weather changes.

During the late fall after the first early storms there is usually a spell of clear weather which offers another favorable period for viewing. Occasional clear weather during the winter makes it possible to carry on some work during the period but it is seldom that work can be continued long enough to carry through an extensive reconnaissance project.

Fall Period - 1917.
September-October-November.

Color of Foliage	Condition of Infestation	Period of Attack.	
Fading and sorrel	Infested	Current season - spring and summer and fall - First and second generations.	1917-1 1917-2
Bright Red	Infested by advanced stages of brood, partially abandoned or abandoned.	Current season - spring and summer first generation	1917-1
Dull red	Abandoned.	Fall of preceding year second generation.	1916-2
Dull red-tops usually black.	Abandoned	Spring and summer of preceding year. First generation.	1916-1
Black	Abandoned	A few trees from first generation of preceding year all trees dead from two to eight years.	1916-1 1915-2 and preceding yrs.

Winter Period - 1917-8
December-January-February.

Fading and sorrel	Infested	Preceding fall second generation.	1917-2
Bright red	Infested by advanced broodsand abandoned	Fall and summer of preceding year - first and second generations	1917-1 1917-2
Dull red - needles drooping.	Abandoned.	Spring and summer of preceding year - first generation	1917-1
Dull red - many needles fallen.	Abandoned.	Fall of second preceding year second generation.	1916-2
Tops black some red needles on lower limbs.	Abandoned.	Summer of second preceding yr.	1916-1
Black	Abandoned.	Includes some trees of 1917 first generation and all preceding years.	1916-1 1915-2 and preceding years.

Cruising Periods
for D. brevicomis in yellow pine
as worked out from Field Records at
Ashland, Ore.

Spring Period - 1917.
March-April-May.

Color of Foliage	Condition of Infestation	Period of Attack.	
Fading and sorrel	Infested.	Preceding fall-second generation.	1916-2
Bright Red	Infested by advanced stages or partially abandoned.	Preceding spring and summer, second generation.	1916-2
Dull red needles drooping but most of them still on.	Abandoned.	Preceding spring and summer first generation.	1916-1
Dull red-turning black at top. Many needles gone.	Abandoned	Fall of second preceding year. second generation.	1915-2
Black	Abandoned	Includes a few trees killed in fall of second preceding year.	1915-2 1915-1 and preceding yr

Summer Period - 1917.
June - July - August.

Fading and Sorrel	Infested	Current season	1917-1
Bright Red	Abandoned	Preceding fall second Generation.	1916-2
Dull red needles drooping and falling.	Abandoned	Preceding spring and summer first generation	1916-2
Dull red top usually black. Many needles gone.	Abandoned	Fall of second preceding year. second generation.	1915-2
Black	Abandoned	Includes a number of trees killed in fall of 1915 and all trees dead two to eight years.	1915-2 1915-1 and all preceding yrs.

Chart Showing Color Phases of D. brevicomis trees.

This diagram is based on records from many trees on the Ashland area and includes the entire period from the 1914 second generation to the 1917 first generation. The percent of trees faded, red and black is shown at any date for each generation, and the extent of the period during which each color phase persists is also shown. The term fading also includes the sorrel stage.

As an example take the 1915-2d generation. These trees began to fade during the spring and by the first of June 100% of the trees had faded. Trees of this generation with fading foliage persisted, however, until about the middle of July. A few trees of this generation turned red before the winter period, but by far the greater part of these trees turned red during the spring of 1916. 100% of the trees were red by the last of July and some trees of this generation still retained red foliage until the fall of 1917. Black top trees of this generation first appeared in the winter of 1916 and during the fall of 1917, 100% reached the black top stage.

In its application in reconnaissance work this table shows approximately the generations to which the fading and sorrel top and red top trees belong at any period during the year. Take the summer period of 1917 as an example. If a count of all fading and red top trees is made during August of this period the generations to which they belong would be as follows:

Fading trees - 1917 first generation.
Red trees - 1916 second generation - includes practically all trees of of this generation
1916 first generation - includes 75% to 90% of the trees of this generation, a few of which have turned black.

The period of loss represented by fading and red foliaged trees is therefore about two years. The same data can be determined for any other period.

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